Journal of Field Archaeology

ISSN: 0093-4690 (Print) 2042-4582 (Online) Journal homepage: http://www.tandfonline.com/loi/yjfa20

Reflections on Collaborative Archaeology and Large-Scale Online Research Infrastructures

Holly Wright & Julian D. Richards

To cite this article: Holly Wright & Julian D. Richards (2018) Reflections on Collaborative Archaeology and Large-Scale Online Research Infrastructures, Journal of Field Archaeology, 43:sup1, S60-S67, DOI: 10.1080/00934690.2018.1511960

To link to this article: https://doi.org/10.1080/00934690.2018.1511960

Published online: 08 Nov 2018.

JOURNAL OF FIELD ARCHAEOLOGY
2018, VOL. 43, NO. S1, S60–S67
https://doi.org/10.1080/00934690.2018.1511960

Reflections on Collaborative Archaeology and Large-Scale Online Research Infrastructures

Holly Wright and Julian D. Richards

University of York, York, UK

ABSTRACT

The Archaeology Data Service (ADS) is an archive working at a national level in the UK, ensuring that archaeologists have access to high quality and dependable digital resources, including openly licensed legacy data for reuse. The ADS acts as a metadata aggregator for archaeological data held by larger heritage agencies and smaller regional organizations and participates in international aggregation infrastructure projects such as ARIADNE, which allows users to access archaeological resources held in many countries from a single interface. Large-scale infrastructures can facilitate the building of long-term, complex relationships and active collaborations, not just technical solutions. This paper reflects on the roles of stewardship and equity within ARIADNE and the ADS, two large-scale online research infrastructures, and how these types of infrastructures may help to create a more collaborative archaeology, including lessons learned, challenges and opportunities, and thoughts for the future.

KEYWORDS

Collaboration; data management; infrastructure; sustainability; archive

Introduction

Online research infrastructures attempt to combine resources in ways that increase accessibility and afford new conclusions. Within archaeology, there is continued emphasis on technological and methodological innovations themselves rather than on the complex social factors that contribute to their success or failure and the connections they facilitate, but this has begun to change. There has been significant recent discussion focused on infrastructures within the digital humanities and particularly within digital heritage, including critical histories and exemplars across edited volumes (Benardou et al. 2017a; De Santo et al. 2017). Most useful for this discussion is the expansion on an idea set out by Eric Champion in 2014 (as discussed in Benardou et al. 2017b) around understanding digital infrastructures as scholarly eco-systems. Such eco-systems are "not merely collections of research resources or tools to conduct research: they are energized by a community of research institutions and individual researchers, and become living environments of evolving, synergistic but also often competing research, education and communication practices" (Benardou et al. 2017b: 3). Online research infrastructures can act as catalysts to bring together different communities of expertise and interest, but can also make explicit areas of disagreement and inequity. The collaborative work required to build or maintain an online research infrastructure in the long-term is often as valuable as the infrastructure itself, particularly with regard to collaboration around advocacy (Ross 2017: 164). It can serve to improve the quality of the online resources within the infrastructure and the underlying research, while also creating more resilient stakeholder communities, which, in turn, help to make the resources within the infrastructure more sustainable. This special issue focuses on how infrastructures can facilitate collaborative archaeology, but collaboration is not necessarily an end unto itself; infrastructures and collaboration can often form a virtuous circle.

Online research infrastructures may be created to incorporate resources around a single project or topic, or they may incorporate many, perhaps even thousands of archaeological interventions or subjects. Other papers within this issue will provide discussions of the former, emphasizing the ways in which creating an online research infrastructure may have informed research choices or new ideas around open data for different user groups, but this paper will focus on the latter. It will reflect on how the creation of persistent, large scale, online research infrastructures, combining data from disparate archaeological sources, can be part of a scholarly eco-system, facilitating those who would advocate for a more collaborative archaeology by focusing on two pressing issues: stewardship and equity.

Stewardship

Stewardship is often used as an overarching practical and general term to describe issues around data preservation and dissemination, but it is used less often in discussions around responsibility. Data ownership and data openness are currently a main focus within online research infrastructures, but the questions of who should be responsible, and why, from a best practice standpoint, are rarely at the fore. The rise of the open data movement has begun to reshape practice for individual researchers and research projects, and the idea that research data should be made open once the researcher has had sufficient time to publish is becoming more accepted, but within archaeology, who should hold the data in the long-term and how it should be disseminated does not receive the same attention and discussion. This is partly a symptom of archaeological data types being unusually

CONTACT Holly Wright holly.wright@york.ac.uk Archaeology Data Service, Department of Archaeology, University of York, The King's Manor, Exhibition Square, YO1 7EP, UK.

diverse, necessitating difficult decisions, but also reflects a continued valuing of ownership over stewardship. Researchers, research projects, and organizations usually have the best intentions with their data, but rarely ask hard questions about their own stewardship capacity: whether they are truly best placed to care for the data in the long term.

In addition, archaeologists are operating in a research environment that makes an assumption of data persistence: that once made freely accessible online, digital resources will continue to be available for use and reuse. In practice, this is the exception rather than the rule. Research infrastructures for archaeology are still typically funded on a project-by-project basis, or through national or regional initiatives, which are subject to changes in political and funding priorities. Lack of persistence has been explored by Law and Morgan (2014), with most project-led resources disappearing online within a few years after completion of the funded portion of a project, and only some being migrated to another online platform. In addition, the project-by-project model does not always lend itself to building lasting collaborations that facilitate stewardship. Funding schemes often stipulate working with different partners with different strengths, and may limit the countries or types of partners that may be involved, resulting in pressure to constantly change the nature of our collaborations. This can both drive and hamper innovation, as new collaborative partnerships may generate new solutions and new connections, but this preference for constant change may also prevent successful collaborations from continuing from one project to the next, making stewardship more challenging.

Despite these difficulties, funders and organizations are increasingly focused on sustainability planning. This is positive, but often unrealistic. Funding priorities tend to favor innovation over maintaining or upgrading existing infrastructures and securing funding from non-traditional sources is difficult. Archaeologists are continually encouraged to find ways to make their work marketable within commercial frameworks and this is invariably part of any sustainability plan, but rarely produces significant revenue. Successful models for the long-term stewardship of archaeological data remain limited.

Equity

Related to stewardship, and also in need of more attention, is equity. Conversations about equity usually focus on equity of access by user communities to resources held by online research infrastructures. While that issue is very important, this discussion will focus on equity of access for data providers, which also has ramifications for creating a more collaborative archaeology. The adoption of digital methods has resulted in the creation of primary data in digital form, derived through the documentation of a physical resource that may be destroyed as a result of its investigation. As the data created to document archaeological interventions are increasingly "born digital," the well-known issues around the fragility and obsolescence of digital resources (Richards 2002) become more pressing. A variety of online research infrastructures with a long-term remit have been developed at the regional, national, and international levels and work to serve their communities, but still only incorporate a small proportion of the digital archaeological data that exists. In fact, most archaeological projects and practitioners lack the resources to engage with best practice or participate in online research infrastructures, as support for stewardship of their data is often lacking or non-existent. This means some archaeological research data is at risk in all countries, regions, and communities, but in most countries, all data is at risk. This lack of equity has become more visible through the work of international online research infrastructures, where researchers contributing data are better able to see the differences in technical and knowledge-based capacity between partners, representing both a major challenge and a collaborative opportunity. It has also surfaced a secondary challenge, which is lack of equity around knowledge and resources allowing participation in infrastructure projects at all, causing the exclusion of potential partners who would most benefit from involvement in projects and funding. Meanwhile, expectations around innovation continue to raise the bar to entry, making it ever more difficult to join the collaborative conversation as time goes on.

To better examine issues of stewardship and equity and the opportunities for a more collaborative archaeology afforded by large-scale online digital infrastructures, this paper will discuss observations on stewardship derived from the work of Archaeology Data Service (ADS), an archive for archaeological data based in the United Kingdom, and observations on equity derived from participation in Advanced Research Infrastructure for Archaeological Dataset Networking in Europe (ARIADNE), a project funded by the European Commission's 7th Framework Programme (ARIADNE 2017), to create a European infrastructure for archaeological data. It will use these two infrastructures as a lens to explore experiences and lessons learned, followed by thoughts and actions for the future.

Stewardship within a National Infrastructure: The Archaeology Data Service

Established in 1996, the ADS is one of several discipline-specific archives originally set up within the Arts and Humanities Data Service (AHDS) in the UK. The AHDS was funded by the Arts and Humanities Research Council (AHRC) and the Joint Information Systems Committee of the Higher Education Funding Councils for England, Scotland, and Wales and the Department of Education for Northern Ireland (JISC). The ADS was founded by a consortium that includes the Council for British Archaeology and eight UK universities and is based at the University of York. The work of the ADS is currently guided by a management committee made up of representatives across its stakeholder communities. In 2008, the AHRC and JISC ceased funding the AHDS due to changing policy priorities, but taking into account the non-repeatable nature of most archaeological research and the need to preserve what was typically primary data, the AHRC recognized that the stewardship needs for archaeology differed from other arts and humanities communities and continued support for several more years, to allow a transition to a self-funded organization (Richards 2017).

The ADS archive was built using standards such as the Open Archival Information System (OAIS) reference model and holds the Data Seal of Approval denoting a trusted and sustainable digital archive. The ADS holds and freely disseminates over 1000 data-rich archives, over 18 journals and series, and more than 45,000 unpublished fieldwork reports created by over 100 professional archaeological contractors. ADS also acts as a resource discovery aggregation platform

for data held by other UK heritage agencies, allowing users to search across over 1.3 million metadata records, linking to over 30 national and regional historic environment inventories. Since 1999, the ADS has also been publishing the Guides to Good Practice (Mitcham et al. 2010), written in collaboration with experts in the many data types with which archaeologists typically work.

Stewardship means taking care of an organization or resource. Within archaeology, this includes conversations about data ownership and responsibility. The existence of the ADS as an online research infrastructure has facilitated collaborative conversations with researchers, heritage agencies, and funders about what stewardship means for archaeological data, including who owns it and who should be responsible for it in the short and long term. This conversation is ongoing, but data stewardship at the ADS typically takes the form of deposition of a resource when the resource is no longer in active use, usually upon completion of an individual project.

Stewardship of Individual Archives

Once the resource is deposited, it goes through an accessioning and archiving process and, unless it is under temporary embargo, it is freely and openly disseminated according to an agreement made between the ADS and the depositor, via a deposit license. The depositor always retains data ownership and copyright, but maintaining the resource in a usable way in perpetuity becomes the responsibility of the ADS. This illustrates a clear division in stewardship capacity best practice. In a project-by-project funding environment, the researcher is responsible for carrying out the research and the ADS is responsible for ensuring that the resource is preserved and disseminated in the long term, allowing the researcher to move on to the next project. Resources archived by the ADS can be mirrored in project websites or incorporated into other infrastructures as the researcher sees fit, with the knowledge that the ADS continues to take responsibility for maintaining the archive. Collaborative conversations about stewardship with funders mean that the cost of preparing an archive for deposit and the one-time archiving fee are often included in project proposal budgets.

Working over the long term has allowed mutual responsiveness and adaptation across multiple communities. As funders and researchers have become more receptive to the idea that data stewardship means not just preserving data for future research, but making it freely and openly available, opportunities for collaborative discussion have increased. For example, a researcher who is initially resistant to the idea of freely disseminating their data might decide that data available from the ADS was useful in their research and start to change their mind about making their own data available. They might get in touch with the ADS staff to discuss how to go about preserving and disseminating the data from their next project, and the ADS staff might, in turn, learn about a new technical or intellectual property issue they had not considered in conversations with the researcher. A conversation might then begin with a potential funder for the research about this new consideration, which may result in modifications in their funding process or changes in their stewardship compliance requirements. All this may happen over a series of years, reflecting the importance of responsiveness and being able to take a long view in developing best practice.

Supporting Collaborative Stewardship

In addition to collaboration around individual archives, the existence of the ADS as a persistent online research infrastructure has created opportunities for collaboration with national and regional heritage and funding agencies. The ADS has become part of the workflows of these agencies, providing a trusted repository for the research they support, and, in turn, the remits of these agencies have also become embedded in the ADS workflows. Adaptation and responsiveness to the changing needs of these agencies over the long term has meant the ADS infrastructure has become a conduit for collaborative solutions that maximize the limited resources across the UK archaeology sector.

A major example is the OASIS system. OASIS began as way to automate compliance procedures within development-led archaeology, where practitioners must provide information about their investigations to local Historic Environment Records (HERs) or national heritage bodies. OASIS provides an online index of the large number of unpublished fieldwork reports (often referred to as gray literature) produced as a result of developer funded and volunteer fieldwork, representing the majority of archaeological work carried out in the UK. Working in collaboration with Historic England, Historic Environment Scotland, and the Royal Commission on the Ancient and Historical Monuments of Wales (Richards and Hardman 2008), the ADS was able to add preservation and dissemination of these reports to the existing compliance workflow, resulting in the over 45,000 reports now freely available online.

As this workflow has become more established in recent years, the number of reports coming through the system continues to increase, and now averages around 500 per month. To accommodate this increase, the OASIS partners are currently undertaking a major redesign of the system to update and expand its functionality (Richards 2017) resulting in an intensive collaborative process which will have a role in defining the nature of professional archaeological work in the UK now and in the future. The context for this collaboration was closely examined in an impact assessment to understand the economic value of the ADS to UK archaeology, particularly the OASIS collaboration. One of the primary conclusions of the assessment was that a significant number of development-led archaeological field units now rely on the ADS Library of Unpublished Fieldwork Reports within their costing and business models, showing how stewardship of these reports has now been adapted into commercial workflows (Beagrie and Houghton 2013).

Leveraging Stewardship

While the ADS takes the view that individual research projects should be deposited with an appropriate archive or repository for long-term stewardship, often local, regional, or national authorities must retain legal ownership of digital archaeological resources and may have their own online research infrastructures. The ADS has worked to promote the stewardship needs of archaeological resources held by other organizations in the UK by aggregating resource discovery metadata from regional and national organizations so that

it can be cross-searched alongside resources held by the ADS. In turn, the ADS provides this metadata to larger online research aggregation infrastructures, such as Europeana and ARIADNE. This means that when a depositor archives and disseminates their resource with the ADS or an organization uses the ADS as an aggregator, that resource is often findable through collaboration with larger international online research infrastructures. This raises the profile of collaborative partners internationally and informs and improves the resources and knowledge base within both infrastructures. For example, moving data from one infrastructure into another often exposes problems with how data or metadata is structured that might not be noticeable otherwise, but that can cause expensive and time-consuming problems in the long term.

The ethos of responsiveness and adaptation that the ADS works to implement allows stewardship solutions to be flexible rather than proscriptive. There is a tension with this approach however, as the more customized the relationship, the more it relies on time and expertise, which has financial implications. Finding the right balance between a necessary and productive level of collaboration with depositors and providing more automated or off-the-shelf solutions to lower costs are areas of constant debate. This is where working with sister services, such as Data Archiving and Networked Services (DANS) in the Netherlands (Hollander 2017) or tDAR in the USA (McManamon et al. 2017), is very productive. Working together helps infrastructures create costing models and provide the right services to best meet the needs of depositors and user communities while remaining financially solvent as organizations. A shared understanding of stewardship and best practice at the organizational level allows shared solutions and learning from mistakes together.

Stewardship and Best Practice

Adaptive collaboration has also been critical to developing best practice and stewardship guidance at the researcher or project level. Working with archiving standards organizations such as the Digital Preservation Coalition (Digital Preservation Coalition 2018) and the Digital Curation Centre (Digital Curation Centre 2017) to develop data management guidance specifically for archaeology, the ADS continues to provide and update the Guides to Good Practice (ADS 2017b). The comprehensiveness of the Guides is made possible through collaboration with partners like tDAR and DANS (Jeffrey 2012), along with many other international contributors. Ongoing collaboration around good practice means that consensus can be built across areas of expertise and limited resources within the sector can be maximized. It also creates a place to focus a community of best practice. Guidance is constantly in need of reevaluation and revision as archaeological practice is always changing.

Stewardship, Sustainability, and Resilience

In the transition to being a self-funding organization, working collaboratively has also allowed diversification of funding sources, which has been critical in creating financial resilience and contributing to overall sustainability. It is more cost-effective to have a single, stable source of funding, as pursuit of funding takes time away from other core tasks (Carroll and Stater 2008), but having to focus creatively on funding has opened up new and more international collaborations.

The ADS has been an active partner in 12 international research projects over the last 10 years, along with several UK-based research projects. Taken as a whole, this means that the ADS is now part of a collaborative community, with over 100 partners spanning dozens of countries. The ADS has benefitted significantly from being part of this international community. It has widened our perspective and created a better understanding of the challenges faced in other countries where archaeological practice may differ greatly. Staff have been able to enhance their skills and interests through participation in research, which would not otherwise be possible as part of the core activities of the ADS archive, building greater capacity within the organization. Access to a strong international research community has also allowed the ADS to contribute contacts, ideas, and resources to domestic partners and stakeholders who might not otherwise have access to them, all of which has contributed to organizational resilience and sustainability beyond the benefit of the funding itself.

Equity within an International Infrastructure: ARIADNE

One of the largest international projects within which the ADS has been a partner is the ARIADNE infrastructure. The first phase of ARIADNE was a four-year project, funded by the European Commission's 7th Framework Programme, with the core remit to create a European infrastructure for archaeological data. It consisted of 17 work packages, most of which focused on delivering the infrastructure, while others represented best practice research around related aspects of data management and dissemination (Aloia et al. 2017; Meghini et al. 2017). ARIADNE was coordinated by PIN Scri - Polo Universitario "Città di Prato" at the University of Florence, with the ADS acting as deputy coordinator. The initial phase consisted of 23 partners across 16 European countries, with over 15 associate partners joining the project during and after its first phase of implementation. The stewardship model for ARIADNE is an online aggregation infrastructure, bringing together resource discovery metadata, allowing users to access locally held resources in the different regions and countries represented by the ARIADNE partners and associate partners.

The European Commission places international collaboration as a central tenet within most of its funding initiatives, and the infrastructures theme is no exception. ARIADNE had nine technical partners, all of whom had to work with each other and with the archaeological partners, each having unique data sets to contribute. This required forging new and expanded relationships and using pragmatic problem solving to find acceptable implementation solutions for all partners. ARIADNE had a detailed work plan, but this level of collaboration around an online research infrastructure had not been tried before within archaeology; therefore, working together was a major aspect of the project.

Projects combining the archaeology and computer science domains are often tasked with showing technological innovation, while less appreciation is placed on the unique intersection afforded by the collaboration between the two fields. For ARIADNE, the technological innovation was challenging, but the collaborative innovation was equally so. Setting aside

the differences of opinion that naturally arise from working through an untried process, most challenges arose when trying to accommodate the diverse workflows in use by archaeologists. Europe has different schools of practice that vary from country to country, and different legal and social traditions with regard to the divisions between academic, development-led, and community archaeology. Archives and repositories are typically based in one country, but for ARIADNE, partners had to cooperate to make their data interoperable in new ways and across national borders.

As the project progressed, there was increasing discussion about the variability in capacity among the data-providing archaeological partners, which was found to be greater than was initially understood. All data-providing partners encountered challenges in how best to map and organize their metadata in order for it to be incorporated and made discoverable within the ARIADNE portal, but some partners encountered greater barriers than others. These included lack of technical capacity in preparing their data; lack of background in data stewardship; and lack of an appropriate, persistent repository to house their data. Despite initial frustrations, several partners came to see this an opportunity, using the collaboration within ARIADNE as a form of leverage to improve their existing organizational practices or to create better infrastructures for their data. New resources were created or improved using the funding and shared expertise within the network, not only helping partners participate in ARIADNE, but also leaving their institutions, regions, or countries with more complete or accessible resources internally. One of the best examples is the Hungarian National Museum, which used ARIADNE partnership and access to its collaborative community not only as an opportunity to prepare digital archaeological resources for resource discovery within the aggregation infrastructure, but also as impetus to create their own online research infrastructure, disseminating their archaeological data online via their own institution for the first time (archeodatabase.hnm.hu).

Beginning the Equity Discussion

Two of the ARIADNE partners saw lack of equity as an issue that needed to be fully articulated within the partnership and beyond. As part of the ARIADNE session for the Italian Semester of Presidency of the European Union International Conference on Research Infrastructures and e-Infrastructures for Cultural Heritage, Benjamin Štular from the Institute for Archaeology, ZRC SAZU (Research Centre of the Slovenian Academy of Sciences and Arts) and Anthony Corns from the Discovery Programme in Ireland presented a paper titled "Impressions from the ARIADNE Community." They described the lack of equity they saw across the ARIADNE partnership with regard to access to a persistent and appropriate archive or repository for their digital data in their home countries, and stated that there were countries that were "haves" and "have-nots" within Europe. For example, the UK, the Netherlands, and Sweden were "haves," whereas most European countries, including the countries they represented, Ireland and Slovenia, were "have-nots." For the "haves," at least some percentage of digital archaeological research data in their country was being saved for future use and reuse, but for the "have-nots," potentially all could be lost (Štular and Corns 2014).

While addressing equity within the partnership was not part of the official ARIADNE workplan, discussions were followed by a proposal from several partners to work together to better understand the issues and take action, and it was determined that data management workshops in partner countries would be a useful way to begin. The author partnered with Kate Fernie from 2Culture Associates, offering to run in-country data management workshops for partners who wished to host them. There was sufficient time and funding to run two workshops, one in Vienna and one in Ljubljana. These were based on data management workshops and materials developed by the ADS and the DCC, augmented by the presenters for the intended audience.

During the planning, it was agreed that the workshops should include an overview of the current data stewardship situation in each country, to provide context for the data management discussions. Edeltraud Aspöck of OREA - Institute for Oriental and European Archaeology at the Austrian Academy of Sciences, and Benjamin Štular from ZRC SAZU in Slovenia not only acted as hosts, but also used the ARIADNE collaboration as a way to start a conversation about creating a persistent archive or repository appropriate for archaeological data within their countries. As a result, both workshops had large turnouts and the attendees were very engaged about every aspect of stewardship.

The participants cited the following primary reasons for attending: pressure on researchers from institutions to deposit data in a persistent repository, and from funders to deposit data for open access dissemination; lack of guidance on what constitutes compliance for data deposit; funders willing to cover costs of data management and deposit, but lack of guidance for depositors in data management planning; and lack of an appropriate archive or persistent repository able to accommodate archaeological data.

Equally important were the presentations given by Aspöck and Štular, who carefully researched and presented the current archaeology data stewardship landscape within their respective countries for the first time. Attendees included archaeologists and technical staff directly involved with data handling, alongside governmental and institutional stakeholders who would be a necessary part of any future solution. Attendees also took the opportunity to speak with each other about how to approach these changes in practice, which were a source of uncertainty for those working in isolation. They also felt positively about learning that there was a larger best-practice community with which they could engage (Aspöck et al. 2016).

Results of the Equity Discussions

After the workshops, conversations continued both within countries and within the ARIADNE partnership on how to proceed. In both Austria and Slovenia, work towards greater stewardship of archaeological data moved forward. In Austria, researchers from the Austrian Academy of Sciences and the University of Innsbruck worked together to create a case study, building a stewardship exemplar for a specific project (Aspöck et al. 2015). In Slovenia, there was experimentation with the creation of a database to form the basis of an archive within ZRC SAZU and the Centre for Preventive Archaeology at the National Heritage Office (CPA ZVKD) began developing a registry of field- and desk-based assessments (Štular 2015). ARIADNE partners also used what

was learned at the workshops to inform a survey to better understand the stewardship landscape for archaeological data in Europe, and were able to collate and analyze responses from over 20 countries. The online availability of unpublished fieldwork reports, excavation registers, and sites and monuments registers was surveyed, with the conclusion that their availability was very rare, and confirming the suspicion that lack of equity was even more widespread than was previously known (Fentress et al. 2016).

The ARIADNE partnership generally, and the in-country data management workshops specifically, made clear that there must be variability in stewardship models. Equity would not be built through a single proscriptive solution. The ways archaeological work was funded and undertaken and which stakeholders should be taking responsibility for stewardship varied greatly between countries and even regions. In addition, those who wanted to take action could find themselves isolated and, in many instances, junior voices in the discussions about new models for working practice, making collaboration and the formation of a community of practice even more important.

Equity Initiatives after ARIADNE

Based on the positive response to the data management workshops and the information returned by the survey, ARIADNE partners determined that the creation of persistent archives and repositories able to accommodate archaeological data was urgent, and that the timing was opportune. Before the first phase of ARIADNE came to a successful close in 2017, plans were already in place to move forward with funding proposals to create a broad collaborative network, including colleagues in North America and other countries outside of Europe.

Future Challenges

Using the lessons learned through participation in large-scale online research infrastructures to create a collaborative network, four interrelated focus areas and objectives have emerged:

Stewardship of archaeological data

Objective: To bring together archaeologists with varying levels of experience to share their successes and challenges around the stewardship of archaeological data. Practical and ethical considerations should be explored, including encouragements and resistances to sharing data and making them openly accessible within archaeology, and who is legally required to fund the short-and long-term costs of preservation. This international conversation would be the starting point for those wishing to begin or progress dialogue in their region or country.

Planning for persistence

Objective: To identify the practical and technical issues surrounding the creation of an appropriate repository for archaeological data. This ranges from understanding hardware and software options for those wishing to initiate a repository in their region, country, or organization, to management structures and the training of archivists. This objective includes identifying existing best practice, changing future needs, and pragmatic technical and structural solutions.

Preservation and dissemination best practice

Objective: To understand current international best practice with regard to archiving and dissemination and its implementation by existing repositories. It includes best practice using the FAIR (Findability, Accessibility, Interoperability and Re-usability) Principles (Wilkinson et al. 2016) and other international standards, along with repository accreditation, cost modelling, and issues surrounding the forms of data generated and used within archaeology. It also includes sharing of current practice and surveying of future trends to understand the changing archaeological and digital landscapes (domain and technology watch).

Use and reuse of archaeological data

Objective: To understand how to optimize archives and interfaces to maximize the use and reuse of archaeological data, and to explore how archaeological archives can better respond to user needs and ways to document and understand both quantitative and qualitative reuse. This includes exploring barriers to reuse, such as intellectual property rights and licensing, but also the design of underlying data structures and their interfaces. It focuses on how to ensure reuse is balanced with the other FAIR Principles; on technologies that improve and optimize searching; on issues around how data is created, organized, and disseminated; on different options for interface design; and on developing best practice, particularly around qualitative reuse.

These four focus areas and objectives represent a response to the current landscape, based on experiences within the ADS and the ARIADNE project around stewardship and equity, but it is also worth noting the direction of future innovation for large-scale online research infrastructures, which will impact our scholarly eco-system. As interoperability of archaeological data was the major challenge of the last decade, reuse will be the major challenge for the next decade. It will no longer be sufficient to preserve and disseminate interoperable archaeological resources persistently (Webster 2018): stewardship will need to extend to demonstrable quantitative and qualitative reuse. This challenge has been well articulated recently (Faniel et al. 2018; Huggett 2018; Kansa and Kansa 2018) and the complexities discussed will significantly effect how we approach collaboration around stewardship and equity.

Conclusions

Persistent, large-scale, online research infrastructures have a role to play in creating Champion's scholarly eco-system and advocating for a more collaborative archaeology; driven by a "community of research institutions and individual researchers" working together to support stronger stewardship and greater equity (Benardou et al. 2017b). Working as a community will allow us to speak with a more unified voice to address barriers and create change. Building relationships within the community and thus promoting responsiveness and adaptability will be important. Ideas that currently seem intractable and efforts that seem impossible may be

movable in the future as the social landscape changes. Emphasizing stewardship and equity makes it easier to take a long view of what is possible, even while we must focus project by project, and gives us the patience to wait.

Acknowledgments

This paper consists of the reflections and observations of the authors, but is a response to years of work carried out by every member of staff, past and present, of the Archaeology Data Service. It is also based on many conversations and lessons learned from working within the ARIADNE partnership, coordinated by Franco Niccolucci of PIN at the University of Florence. We are very grateful to both the ADS staff and the ARIADNE partners for their generosity of ideas and willingness to support our thinking and actions around collaboration. In particular we wish to thank Kate Fernie of 2Culture Associates for her support and hard work in designing and implementing the ARIADNE data management workshops in Vienna and Ljubljana with us. We would also like to thank Edeltraud Aspöck of the Institute for Oriental and European Archaeology (OREA) at the Austrian Academy of Sciences and Benjamin Štular from the Institute for Archaeology, ZRC SAZU – Research Centre of the Slovenian Academy of Sciences and Arts for organizing and participating in the very inspiring workshops. Being part of the ADS and ARIADNE has meant learning from the collaborative understanding of literally hundreds of people. We have gained understanding and support from everyone, directly and indirectly, and we are very grateful to you all.

Disclosure Statement

The content of this article does not reflect the official opinion of the European Union. Responsibility for the information and views expressed lie entirely with the authors.

Funding

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007- 2013) under grant agreement number 313193.

Notes on Contributors

Holly Wright (Ph.D. 2011, University of York) manages collaborative research for the Archaeology Data Service, including participation in the ArchAIDE, NEARCH, E-RIHS, ARIADNE, LoCloud, CARARE, and SENESCHAL projects. She holds an M.Sc. in Archaeological Information Systems and a Ph.D. in Archaeology, focused on archaeological field drawing and the Semantic Web. Her areas of research specialization are visual documentation and communication, archaeological data management, and the use of Web standards and the Semantic Web in archaeology.

Julian D. Richards (Ph.D. 1986, CNAA) is Professor of Archaeology at the University of York. His direct involvement in archaeological computing began in 1980 when he started his PhD research studying pre-Christian Anglo-Saxon burial ritual using the computing power of an ICL mainframe and an early Z80 micro-computer. In 1985 he co-authored the first textbook in archaeological computing for Cambridge University Press, and has subsequently written numerous papers and edited a number of books on the applications of information technology in archaeology. Since 1996, he has been Director of the Archaeology Data Service and Co-Director of the e-journal *Internet Archaeology*. He is Deputy Coordinator for the European ARIADNE e-infrastructure for archaeological research.

ORCID

Holly Wright http://orcid.org/0000-0002-3403-4159
Julian Richards http://orcid.org/0000-0003-3938-899X

References

ARIADNE. 2017. "About ARIADNE." ARIADNE Website. Accessed 2 May 2018. http://www.ariadne-infrastructure.eu/

Aloia, N., C. Binding, S. Cuy, M. Doerr, B. Fanini, A. Felicetti, J. Fihn, D. Gavrilis, G. Geser, H. Hollander, C. Meghini, F. Niccolucci, F. Nurra, C. Papatheodorou, J. Richards, P. Ronzino, R. Scopigno, M. Theodoridou, D. Tudhope, A. Vlachidis, and H. Wright. 2017. "Enabling European Archaeological Research: The ARIADNE E-Infrastructure." *Internet Archaeology* 43. https://doi.org/0.11141/ia.43.11

Archaeology Data Service. 2017a. "Archaeology Data Service: About Us." Archaeology Data Service Website. Accessed 27 April 2018. http://archaeologydataservice.ac.uk/about.xhtml

Archaeology Data Service. 2017b. "Guides to Good Practice." Archaeology Data Service Website. Accessed 27 April 2018. http://guides.archaeologydataservice.ac.uk/

Aspöck, E., K. Kopetzky, B. Horejs, M. Bietak, M. Kucera, and W. Neubauer. 2015. "A Puzzle In 4D Digital Preservation And Reconstruction Of An Egyptian Palace." Paper Presented at *Digital Heritage, Granada,* 2015. https://doi.org/10.1109/DigitalHeritage.2015.7419596

Aspöck, E., B. Štular, H. Wright, and K. Fernie. 2016. "*ARIADNE Data Management Workshops in Vienna and Ljubljana*." ARIADNE Infrastructure. http://www.ariadne-infrastructure.eu/News/ARIADNE-data-management-workshops-in-Vienna-and-Ljubljana

Beagrie, N., and J. Houghton. 2013. "The Value and Impact of the Archaeology Data Service." JISC Website. http://repository.jisc.ac.uk/5509/1/ADSReport_final.pdf

Benardou, A., E. Champion, C. Dallas, and L. Hughes, eds. 2017a. *Cultural Heritage Infrastructures in Digital Humanities*. London: Routledge.

Benardou, A., E. Champion, C. Dallas, and L. Hughes. 2017b. "Introduction: A Critique of Digital Practices and Research Infrastructures." In *Cultural Heritage Infrastructures in Digital Humanities*, edited by A. Benardou, E. Champion, C. Dallas, and L. Hughes, 1–14. London: Routledge.

Carroll, D. A., and K. J. Stater. 2008. "Revenue Diversification in Nonprofit Organizations: Does it Lead to Financial Stability?" *Journal of Public Administration, Research and Theory* 19 (4): 947–966.

De Santo, M., F. Niccolucci, and J. D. Richards, eds. 2017. "Special Issue on Digital Infrastructures for Cultural Heritage." *Journal on Computing and Cultural Heritage*: 10 (1 and 3).

Digital Curation Centre. 2017. "Resources for Digital Curators." DCC Website. Accessed 3 November 2017. http://www.dcc.ac.uk/resources

Digital Preservation Coalition. 2018. "Search Our Knowledge Base." DPC Website. Accessed 3 May 2018. http://www.dpconline.org/knowledge-base

Faniel, I., A. Austin, E. Kansa, S. Kansa, P. France, J. Jacobs, R. Boytner, and E. Yakel. 2018. "Beyond the Archive: Bridging Data Creation and Reuse in Archaeology." *Advances in Archaeological Practice* 6 (2): 105–116.

Fentress, E., E. Aspöck, K. Fernie, and H. Wright. 2016. "*Archiving Initiatives for Archaeological Sites in Europe*" ARIADNE Website. http://www.ariadne-infrastructure.eu/Media/Files/Archiving-Initiatives-for-Archaeological-Sites-in-Europe

Hollander, H. 2017. "Saving Treasures of the World Heritage at the Digital Archive DANS." *Internet Archaeology* 43. https://doi.org/10.11141/ia.43.9

Huggett, J. 2018. "Reuse Remix Recycle: Repurposing Archaeological Digital Data." *Advances in Archaeological Practice* 6 (2): 93–104.

Jeffrey, S. 2012. "A new Digital Dark Age? Collaborative Web Tools, Social Media and Long-Term Preservation." *World Archaeology* 44 (4): 553-570.

Kansa, S., and E. Kansa. 2018. "Data Beyond the Archive in Digital Archaeology: An Introduction to the Special Section." *Advances in Archaeological Practice* 6 (2): 89–92.

Law, M., and C. Morgan. 2014. "The Archaeology of Digital Abandonment: Online Sustainability and Archaeological Sites." *Present Pasts* 6 (1). https://doi.org/10.5334/pp.58

McManamon, F., K. Kintigh, L. Ellison, and A. Brin. 2017. "tDAR: A Cultural Heritage Archive for Twenty-First-Century Public Outreach, Research, and Resource Management." *Advances in Archaeological Practice* 5 (3): 238–249.

Meghini, C., R. Scopigno, J. Richards, H. Wright, G. Geser, S. Cuy, J. Fihn, B. Fanini, H. Hollander, F. Niccolucci, A. Felicetti, P. Ronzino, F. Nurra, C. Papatheodorou, D. Gavrilis, M. Theodoridou, M. Doerr, D. Tudhope, C. Binding, and A. Vlachidis. 2017. "ARIADNE: A Research Infrastructure for Archaeology." *ACM Journal on Computing and Cultural Heritage* 10 (3): Article 18.

Mitcham, J., K. Niven, and J. D. Richards. 2010. "Archiving Archaeology: Introducing the Guides to Good Practice." In *Proceedings of the 7th International Conference on Preservation of Digital Objects*, edited by A. Rauber, M. Kaiser, R. Guenthier and P. Constantopoulos, 183–187. Vienna: Austrian Computer Society.

Richards, J. D. 2002. "Digital Preservation and Access." *European Journal of Archaeology* 5 (3): 343–366.

Richards, J. D. 2017. "Twenty Years Preserving Data: A View From the UK." *Advances in Archaeological Practice* 5 (3): 227–237.

Richards, J. D., and C. Hardman. 2008. "Stepping Back From The Trench Edge: An Archaeological Perspective On The Development Of Standards For Recording And Publication." In *The Virtual Representation of the Past. Digital Research in the Arts & Humanities*, edited by M. Greengrass and L. Hughes, 101–112. Farnham: Ashgate.

Ross, S. 2017. "Digital Humanities Research Needs From Cultural Heritage Looking Forward to 2025?" In *Cultural Heritage Infrastructures in Digital Humanities*, edited by A. Benardou, E. Champion, C. Dallas, and L. Hughes, 153–166. London: Routledge.

Štular, B., and A. Corns. 2014. "Impressions from the ARIADNE Community." *Italian Semester of Presidency of the European Union International Conference on Research Infrastructures and e-Infrastructures for Cultural Heritage*. http://www.otebac.it/internationalconference/index.php?en/66/november-14th

Štular, B. 2015. "Archiving of Archaeological Digital Datasets In Slovenia: Current Practices." ARIADNE Website. http://www.ariadne-infrastructure.eu/Media/Files/Archiving-Archaeological-Datasets-in-Slovenia

Webster, P. 2018. "Book Review: Cultural Heritage Infrastructures in Digital Humanities edited by Agiatis Benardou, Erik Champion, Costis Dallas and Lorna M. Hughes." *LSE Review of Books*. http://blogs.lse.ac.uk/lsereviewofbooks/2018/02/27/book-review-cultural-heritage-infrastructures-in-digital-humanities-edited-by-agiatis-benardou-erik-champion-costis-dallas-and-lorna-m-hughes/

Wilkinson, M. D., M. Dumontier, I. J. Aalbersberg, G. Appleton, M. Axton, A. Baak, N. Blomberg, J. Boiten, L. B. da Silva Santos, P. E. Bourne, J. Bouwman, A. J. Brookes, T. Clark, M. Crosas, I. Dillo, O. Dumon, S. Edmunds, C. T. Evelo, R. Finkers, A. Gonzalez-Beltran, A. J. G. Gray, P. Groth, C. Goble, J. S. Grethe, J. Heringa, P. A. C. 't Hoen, R. Hooft, T. Kuhn, R. Kok, J. Kok, S. J. Lusher, M. E. Martone, A. Mons, A. L. Packer, B. Persson, P. Rocca-Serra, M. Roos, R. van Schaik, S. Sansone, E. Schultes, T. Sengstag, T. Slater, G. Strawn, M. A. Swertz, M. Thompson, J. van der Lei, E. van Mulligen, J. Velterop, A. Waagmeester, P. Wittenburg, K. Wolstencroft, J. Zhao, and B. Mons. 2016. "The FAIR Guiding Principles for Scientific Data Management and Stewardship." *Scientific Data* 3: 160018.